TECHNICAL ANNEXE

CARI-Tune, part by part.

What goes in, what comes out, and what your engineer sees at each step: inputs, grades, settings and margins, the ten control-system styles, approvals and history, the monthly re-check, the readiness column, where it runs, and the worked example in full.

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A1 · WHAT YOU SEND

Inputs, field by field.

CARI-Tune reads the trend export your control system already keeps, a few figures your engineer knows, and the records of two tests your engineer runs. Optional boxes may be left empty; nothing is filled in for you.

The trend export

File	CSV from your DCS, PLC, SCADA or historian. The built-in CARI-Loops health check and CARI-Tune read the same file.
Columns per loop	`Timestamp`, then `TAG.PV` (measurement), `TAG.SP` (set point), `TAG.OP` (controller output) and `TAG.MODE` (auto or manual).
Length and rate	Agreed with CARIMO for the loops in hand. The worked example uses 9 hours at one row every 9 seconds, for three loops in one file.
Scope	One loop or a whole unit. A unit gives one table, worst first, with the same answer for each loop as a loop-by-loop run.
Tag names	Use your own tag names: the program lists the loops it sees and you confirm.
Scaling	Gains are worked out in the units of your export: output per unit of measurement. Export the measurement and the output on the scales your controller block uses for its gain; CARIMO sets this up with you.
Speed	A few seconds per loop.

THE FIRST ROWS OF THE EXAMPLE EXPORT

```
Timestamp,TIC-302.PV,TIC-302.SP,TIC-302.OP,TIC-302.MODE, ... the next loop's four columns, and so on
2026-11-01 01:00:00,122.90991,122.9,35.7868289,AUTO, ...
2026-11-01 01:00:09,122.897594,122.9,35.8253524,AUTO, ...
2026-11-01 01:00:18,122.89174,122.9,35.2922399,AUTO, ...
```

Details for one loop

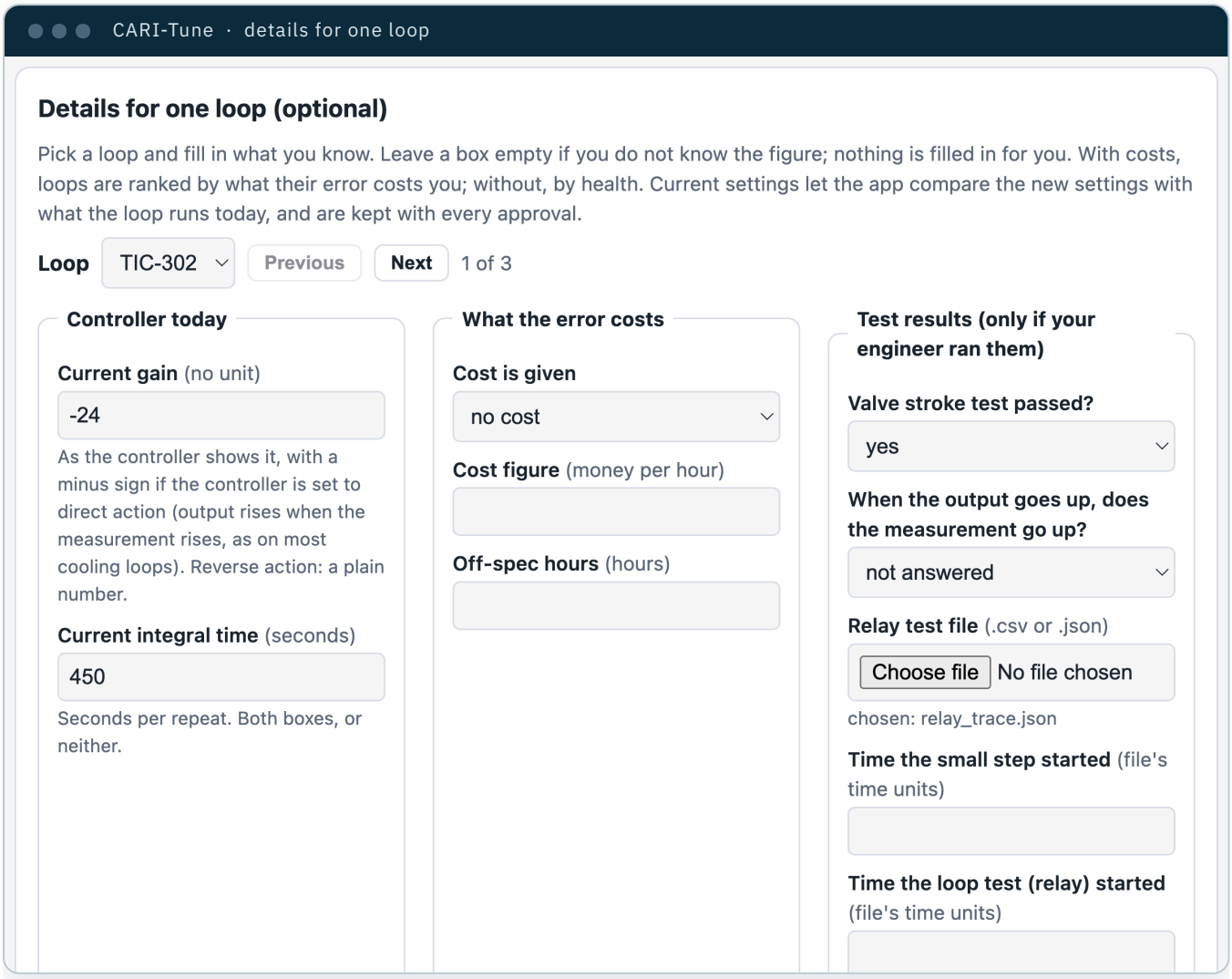
Current gain	The controller gain, with a minus sign for a direct-acting controller (output rises when the measurement rises, as on most cooling loops) and a plain number for reverse action.
Current integral time	Seconds per repeat. Give both boxes or neither. They add today's curve to every picture, and they are needed before approval, so the record holds the setting being replaced.
Cost of error	Either a cost per unit of error per hour, or a cost per off-spec hour, with the off-spec hours. Loops are then ordered by the cost of the error as recorded, worked out from your figure. Negative or unreadable costs are refused by name.
Valve stroke test	Passed: yes or no. Asked only for loops graded for retuning.
Process direction	When the output goes up, does the measurement go up? Yes, no, or not answered. Asked with the test results.
Short loop test file	CSV or JSON with time, output, measurement and set point, recorded by your engineer in three parts: steady running, one small step of the controller output, then the loop test: a few small moves each way around the working point.
Test times	When the small step began and when the loop test began, in the file's own time units.

> **Before the tests.** Your engineer and operating team agree the controller mode, the size of the output moves and the test period. The valve stroke test comes first; the loop test is run only when it has passed.

A1 · WHAT YOU SEND, ON SCREEN

One loop at a time, three small groups of boxes.

Pick a loop, fill in what you know, and press “Work out again with these”. Previous and Next step through the unit. Or press “Try the example” on the opening screen to open the worked example of section A10.



CONTROLLER TODAY

Current gain and integral time. Adds today's curve to both pictures and the “from” value to every change record.

WHAT THE ERROR COSTS

Your own figure, per unit of error per hour or per off-spec hour. Turns health order into money order.

TEST RESULTS

Shown only for loops graded for retuning: stroke test, process direction, the loop test file and its two start times.

SHORT LOOP TEST FILE, CSV

```
time,OP,PV,SP
... one row for each reading of the test
```

One `time` column, then output, measurement and set point for the whole test. The two start times are typed in the file's own time units.

MONTHLY RE-CHECK FILE, CSV

```
time,pv,op,sp
... one row for each reading of the period
```

Time or step, measurement and output are needed; set point if you have it. One file for each recording period of the month.

Checked as you type. The screen names a missing or invalid entry and says what to enter. Column names may be in capitals or small letters.

A2 · GRADES AND THE VALVE-FIRST RULE

Which loops get settings, and which do not.

Settings are given when the health check and the short loop test support retuning. Every other loop gets its reason in words, so no loop is silently skipped.

GRADE ON SCREEN	WHAT IT MEANS	WHAT YOU GET
needs retuning	The record points to the current settings as the cause of the swing.	Three settings with safety margins, two pictures, an answer against today's setting, a settings sheet.
test the valve	The swing looks like a valve that sticks or has play, or may come from outside the loop.	No settings. The valve stroke test to run, and the reason.
instrument first	The record shows a measurement that is frozen or appears to drift.	No settings. The transmitter to check.
no problem found	No tuning issue was found in this record.	Left alone: “nothing to tune”.
could not judge	The record is too short, too coarse or too broken to decide.	Listed apart with the reason. Never reported as healthy.

What each finding leads to

The record points to a sticking valve	Run the valve stroke test first; repair or service the valve if confirmed.
The record points to valve play	Check the valve travel first; repair the valve if confirmed.
The recorded measurement stays unchanged	Check the transmitter and the signal path first.
The loop was in manual	Settings cannot be judged from a record in manual.
The output does not follow the error	Check the controller set-up first.

The gate, step by step

1. **Health check grade.** Only loops whose swing points to their own settings go forward.
2. **Valve stroke test.** Run by your engineer. A valve that fails is fixed first, and the loop gets no settings until it passes.
3. **Short loop test.** One small step of the controller output, then a few small moves each way, run by your engineer. The app says what to export and asks for the file.
4. **Confirmation.** Settings are issued when the loop test supports retuning.

> **Why valve first.** Valve work addresses sticking directly and can restore control before any retune.

WHAT A LOOP WITHOUT SETTINGS SHOWS ON SCREEN

“No settings: test the valve first.”
With the reason from the health check beside it.

“No settings: fix the instrument first.”
With the measurement that froze or drifted.

“A test is needed before settings can be given.”
With the export to make: time, output, measurement and set point for the whole test.

A3 · THE THREE SETTINGS AND THEIR SAFETY MARGINS

Three settings, three stated margins.

What a setting is	A controller gain and an integral time in seconds, for a PI controller, with the action stated.
Slow	The gentlest choice. Stated safety margin: at least 3.5×.
Normal	The middle choice. Stated safety margin: at least 2.67×.
Fast	The firmest choice. Stated safety margin: at least 2×.
Gain and action	CARI-Tune uses a negative gain for direct action and a positive gain for reverse action; the sheet lists the action separately. With no current gain given, new gains are shown as sizes, for the same action as now.

STATED SAFETY MARGIN

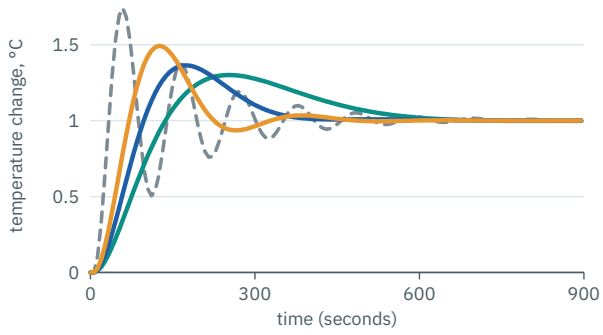


Safety margin here means gain margin: the factor by which the process gain can rise before the predicted response reaches steady cycling. The stated figure is the floor each setting keeps.

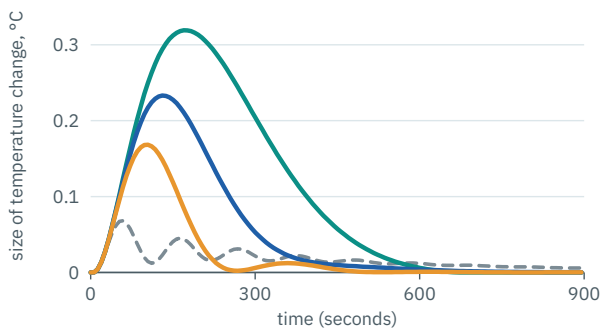
A4 · PICTURES AND THE ANSWER AGAINST TODAY

What each setting does, drawn before anything is changed

Predicted temperature response to a 1 °C set-point step



Predicted response, °C, to a load step of 1 % at the process input



Your setting today — Slow — Normal — Fast

Two pictures per loop	The measurement's predicted response to a step of one unit of set point (1 °C in the example), and to a load step of 1 % at the process input, worked out from the loop test. Time in seconds; the dotted line is the target.
How to read them	A lower peak and a shorter settling time are a calmer answer to a set-point move. A smaller bump after a load, gone sooner, is a firmer hold.
Today's curve	Drawn as a dashed line when the current gain and integral time are given.
Comparison with today	The app's verdict for the Normal setting against today's, on the predicted responses, with its reason in words: better, worse, or too close to call.
Ranking	By health when no cost is given; by money when you give your cost of error. Money shown is the cost of the error as recorded.

A5 · TEN CONTROL-SYSTEM STYLES

Field names and units, as your block shows them.

Each row is the example loop TIC-302 written in one style: the gain field and the integral field, then today's setting and the three new ones as `gain / integral`.

CONTROL-SYSTEM STYLE	GAIN FIELD	INTEGRAL FIELD	TODAY	SLOW	NORMAL	FAST
Generic ISA / ideal textbook form	`Kc`	`Ti (s/repeat)`	24 / 450	2.567 / 227	**3.898 / 181.6**	6.017 / 136.2
Emerson DeltaV PID function block	`GAIN`	`RESET (s/repeat)`	24 / 450	2.567 / 227	**3.898 / 181.6**	6.017 / 136.2
Honeywell Experion / TDC PID	`K (gain)`	`T1 (min/repeat)`	24 / 7.5	2.567 / 3.784	**3.898 / 3.027**	6.017 / 2.27
Yokogawa CENTUM VP PID	`P (PB %)`	`I (s)`	4.167 / 450	38.95 / 227	**25.66 / 181.6**	16.62 / 136.2
Siemens PCS 7 CONT_C / PIDConL	`GAIN`	`TI (s)`	24 / 450	2.567 / 227	**3.898 / 181.6**	6.017 / 136.2
Rockwell Logix PIDE — Dependent gains	`PGain`	`IGain (min/repeat)`	24 / 7.5	2.567 / 3.784	**3.898 / 3.027**	6.017 / 2.27
Rockwell Logix PIDE — Independent gains	`PGain (Kp)`	`IGain (Ki, 1/min)`	24 / 3.2	2.567 / 0.6785	**3.898 / 1.288**	6.017 / 2.65
Foxboro (Schneider) I/A Series PIDA	`PBAND (%)`	`INT (min/repeat)`	4.167 / 7.5	38.95 / 3.784	**25.66 / 3.027**	16.62 / 2.27
ABB 800xA PidCC / PidAdvanced	`Gain`	`Ti (s)`	24 / 450	2.567 / 227	**3.898 / 181.6**	6.017 / 136.2
Generic Reset-rate style (repeats/min)	`Kc`	`Reset (repeats/min)`	24 / 0.1333	2.567 / 0.2643	**3.898 / 0.3303**	6.017 / 0.4405

GAIN OR BAND

Where a system asks for a proportional band, the gain is written as a band in per cent, 100 divided by the gain: 3.90 becomes 25.66 %, right for a measurement span of 100 units.

TIME OR RATE

Seconds or minutes per repeat, repeats per minute, or an integral gain per minute: 181.6 s is 3.027 min, a reset rate of 0.330 repeats per minute, or an integral gain of 1.288 per minute.

ACTION AS A SWITCH

Every style writes the gain as a size and the action as its own column, direct or reverse. For TIC-302 the sheet says direct.

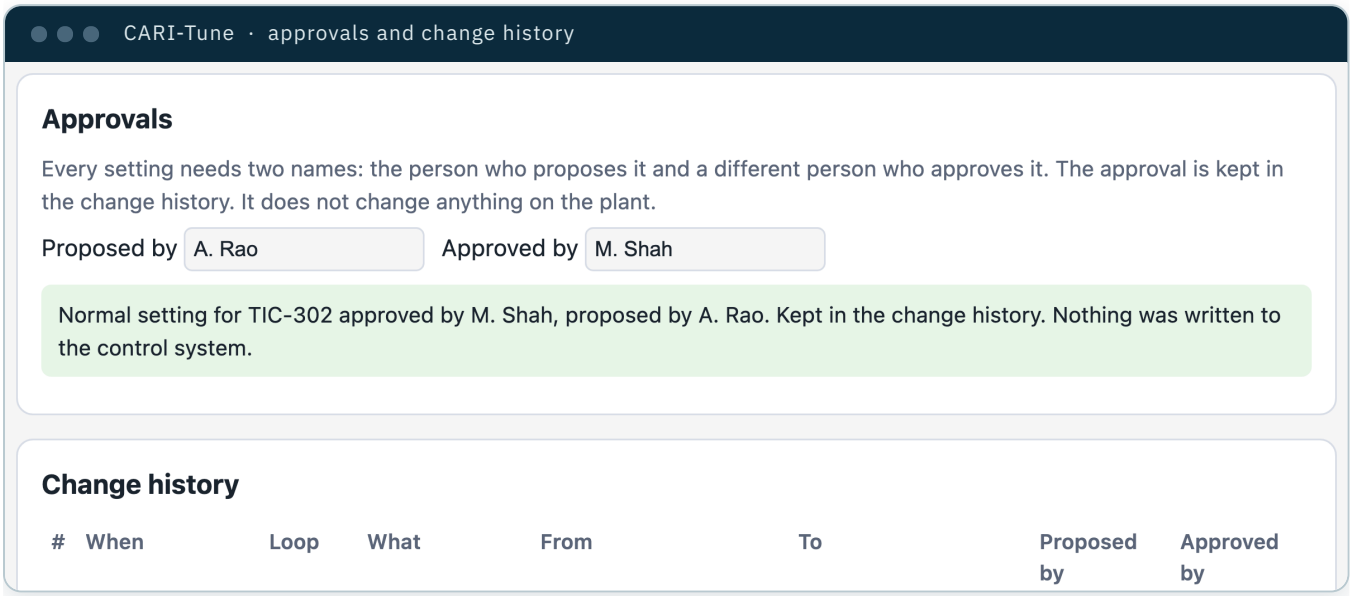
THE CSV, AS DOWNLOADED

```
loop,acting,setting,P (PB %),I (s)
TIC-302,direct,current,4.16667,450
TIC-302,direct,slow,38.9494,227.037
TIC-302,direct,normal,25.6561,181.63
TIC-302,direct,fast,16.6209,136.222
```

Formats	On screen, CSV download, and a printable page.
Per sheet	Loop, action, today's setting and the three new ones; loops with no settings are listed with the reason.
Block options	The sheet states the form it assumed for the block. Gains are in the units of your export; your engineer confirms the block's form, scaling and action before entering anything.
Precision	Six significant figures. Record the controller's read-back value with the change.

A6 · APPROVALS, CHANGE HISTORY AND THE RECORD CODE

A controlled change, from proposal to recorded approval.



What one record keeps

Number	Its place in the history, counted from the first record.
Loop and setting	TIC-302, approval (Normal).
From	gain −24.000, integral 450.0 s
To	gain −3.898, integral 181.6 s
Proposed by, and when	A. Rao, 2026-11-17T08:06Z
Approved by, and when	M. Shah, 2026-11-17T08:06Z
Value entered	The value entered at the controller and read back, when your engineer records it.
Record code	`3f44cdc2 … d4a38637`
Link	The code of the record before it.

The rules it enforces

Proposer and approver	Different proposer and approver names are required; capital letters make no difference. CARIMO sets up sign-in and approval responsibilities with your team.
Old setting needed	An approval is kept with the setting it replaces.
Sealed chain	Every record is sealed to the one before it. The chain is checked each time the history is read; a failed check is reported and the history is not shown.
Damaged history	If the history does not read back, nothing new is written and the screen says so.
Nothing written to the plant	An approval is a record. The setting is entered by your engineer.

THE TAMPER CHECK ON THE PRINT

Change history: 1 change record recorded. Last record code:
`3f44cdc2d583dd7f9ec1d385ef52e2ca199f2bea0a6189e5b7b2d611d4a38637`.

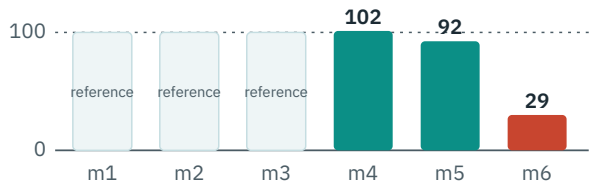
The one-page report records the length of the history and its last record code at that time. CARI-Tune checks the saved chain each time it reads the history. Keep the signed report with your change records, so the saved history can be checked against it later. If the history does not read back, the report says so and prints no code.

A7 · MONTHLY RE-CHECK

Each loop against its own earlier months.

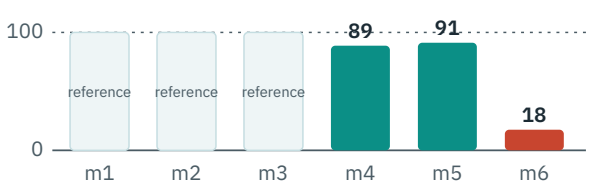
You add	That month's historian readings for a loop: one file for each recording period (window) of the month, CSV or JSON, with time or step, measurement and output; set point and manual flag if you have them.
Loop details	Tag, type (flow, level, pressure, temperature and others) and unit.
Reference months	The first three months are the loop's own reference. From the fourth month, every new month is scored against them.
Verdict words	Better, no change, slower, valve-like, worse.
Health index	100 when the loop behaves as in its own reference months; lower when it is worse. An index, not a percentage: read it with the verdict.
Capacity	Up to 200 loops in one run, 60 months of history per loop, 12 recording periods in a month.
Keeping the record	Keep each month's source files with the loop's plant records. Monthly results are stored locally, in the browser on that PC; to continue on another PC, load the kept monthly files.
A new reference period	After a retune, or whenever your team wants a new baseline, press “Forget stored months” and begin again.

PIC-210 pressure loop · month 6: slower

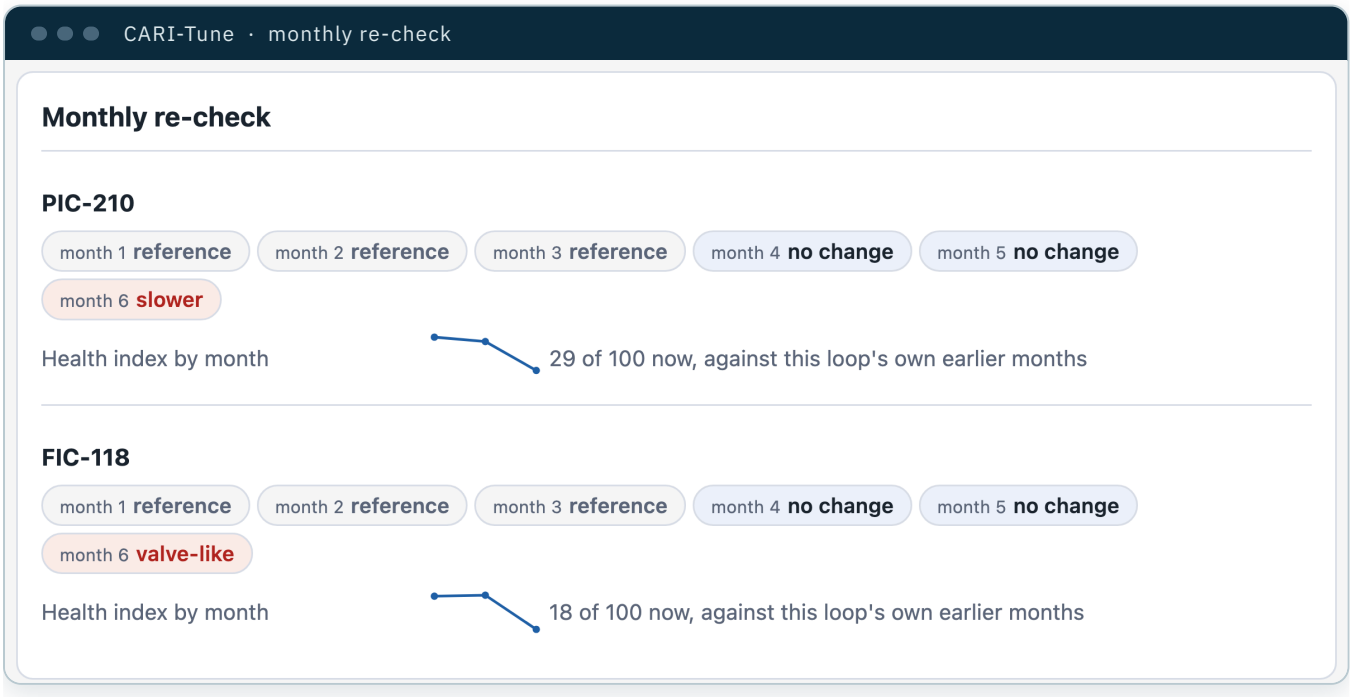


The control has become slower: check whether the gains were lowered.

FIC-118 flow loop · month 6: valve-like



A regular cycle has appeared: check the valve for sticking before any retune.



Two of our own test loops through the app's monthly re-check.

A8 · READINESS BEFORE AN ADVANCED-CONTROL STEP TEST

Base loops first. Then the step test.

Prepare the base loops before committing plant time to an advanced-control test. The readiness column reads what the routine record already shows, loop by loop.

Reads	The same routine record and health check; no extra test.
Names	A loop in manual, a frozen measurement, a sticking valve, valve dead band, an output at its limit, a loop that cycles, a loop that should be tuned first.
Per loop	"Issue found" with each issue in words, or **"nothing found in the routine record"**.
Use	Fix the named loops before the step test, so the test models the process and not the fault.

BEFORE THE ADVANCED-CONTROL TEST

1. **Health check** of the unit's base loops.
2. **Fix** the valves and instruments it names.
3. **Retune** the loops graded for retuning.
4. **Re-check**, then plan the step test.

CARI-Tune · readiness column

Before an advanced-control step test

- **TIC-302**: issue found
  - the loop cycles with its neighbours: the cycle hides the step response
- **FIC-101**: nothing found in the routine record
- **PIC-401**: nothing found in the routine record

The readiness column on the example plant: one loop with its issue named, two that read "nothing found in the routine record".

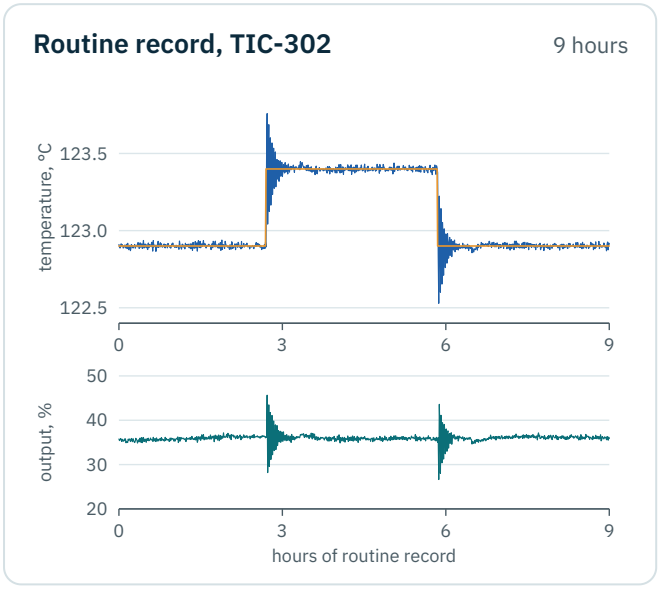
A9 · WHERE IT RUNS, AND YOUR DATA

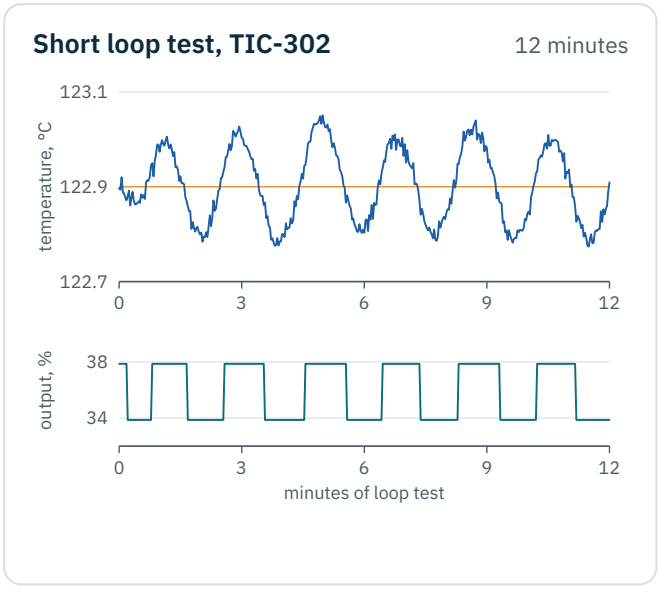
Where it runs	On your own PC, set up with your team, and opened in a web browser.
Your records	Stay on your own PC. CARI-Tune reads exported files; trend review is read-only.
Link to the control system	None needed. Your engineer enters each setting through your own change procedure.
File checks	Done on your PC when the file is read. If something is missing, the screen names it and says how to export it again.
Change history	Kept as a sealed file with the job. Back it up with your other plant records; the printed record count and code support a later check against it.
Names and sign-in	Names are typed on the approvals screen; sign-in is set up with your plant installation.
Worked example	Comes with the app: press "Try the example".

A10 · WORKED EXAMPLE IN FULL

The example job, number by number.

Press “Try the example” in the app and this job opens: a standard published test plant, a chemical plant with reactor loops.





Measured temperature Set point Controller output (to the valve)

Record	3,601 rows, one every 9 seconds, three loops: reactor temperature TIC-302, pressure PIC-401, flow FIC-101.
Health check	TIC-302 swings after every set-point move and is graded “needs retuning”. PIC-401 and FIC-101: no problem found.
Controller today	TIC-302: gain −24, integral time 450 s, direct acting.
Tests by the engineer	Valve stroke test passed. Short loop test file, 12 minutes in all: steady running, one small step, then the controller output moved 2 percentage points each way around 35.9 %; the temperature stayed between 122.77 and 123.05 °C.
Outcome	The valve stroke test passed, and the short loop test supported retuning. CARI-Tune issued three settings.

SETTING	GAIN	INTEGRAL TIME, S	STATED SAFETY MARGIN	SET-POINT PEAK, °C, 1 °C STEP	SETTLES WITHIN ± 5 % OF STEP, S	LOAD PEAK, °C, 1 % INPUT STEP
Today	−24	450.0	not stated	1.74	497	0.07
Slow	−2.567	227.0	at least 3.5×	1.30	529	0.32
Normal	−3.898	181.6	at least 2.67×	1.36	340	0.23
Fast	−6.017	136.2	at least 2×	1.49	294	0.17

Settings and margins are the app's own example output. Example gain units: percentage points of controller output per °C. Load peaks are the size of the predicted temperature change. Peaks and settling times are read from the app's two pictures (section A4); settling is the time after the set-point step to come within 5 % of the step and stay there. Today's setting gives the smallest load bump but swings about the target in the predicted set-point response. Each new setting settles without that swinging and keeps its stated margin: in this example Slow has the lowest peak and Fast the smallest load bump of the three.

A11 · SET UP WITH YOUR TEAM

Who does what, and what stays with you.

Roles

Your process or control engineer	Sends the export, runs the valve stroke test and the short loop test, chooses a setting, enters it from the sheet.
A second person	Approves each change. A different name from the proposer.
CARI-Tune	Grades the loops, gives the three settings with margins and pictures, writes the sheet, keeps the history, re-checks each month.
CARIMO	Sets up the app with your team, maps your tags and control-system style, and supports the first unit.

What the screen always shows

Entry of settings	“Settings are entered by your engineer.”
Writing settings into your control system	Off; set up and tested with your team first.
Automatic retuning as the process drifts	Off; set up and tested with your team first.

1 Send one export	2 Check the valves	3 Choose and approve	4 Enter and check
A trend export of one unit; the health check runs on it.	Stroke test on the loops graded for retuning, then the short loop test.	One of three settings per loop, with two names.	From the sheet. Your engineer checks the read-back and the trend.

A12 · WORDS USED IN CARI-TUNE

Gain	How strongly the controller output answers an error.
Integral time	How quickly the controller removes a lasting error, in seconds per repeat.
Proportional band	100 divided by the size of the gain, on matching per-cent scales for measurement and output.
Action	Direct: the output rises when the measurement rises. Reverse: the output falls when the measurement rises.
Safety margin	The stability margin (gain margin): the room for the process gain to rise before the loop would cycle steadily.
Short loop test	One small step of the controller output and a few small moves each way around the working point, run by your engineer.
Health index	A monthly score for one loop against its own earlier months; 100 is no change.
Record code	The code that seals one change record to the history before it.

START WITH ONE LOOP

Show us one loop. See three settings. Start with a CSV of time, measurement, set point, controller output and mode. Write to **contact@carimo.tech** to agree the export and the first-loop test.

WEB

carimotech.com
CARI-Loops finds the trouble. CARI-Tune is CARI-Loops plus tuning.